

What is claimed is:

1. A ventilation support monitoring method for a ventilator supplying a breathing gas to a patient via a breathing circuit in fluid communication with at least one lung of the patient, the ventilator having a plurality of selectable ventilator setting controls for governing supply of the breathing gas from the ventilator to the patient, each setting control selectable to a level setting, comprising:

receiving at least one ventilator setting parameter signal, each ventilator setting parameter signal indicative of the level setting of one ventilator setting control;

monitoring a plurality of sensors to determine the sufficiency of ventilation support supplied to the patient, each sensor operatively connected to a select one of the patient or the breathing circuit, each sensor generating an output signal; and

determining the desired level setting of at least one ventilator setting control of the ventilator.

2. The method of Claim 1, wherein the output signals are selected from the group comprising: an exhaled carbon dioxide signal indicative of the exhaled carbon dioxide (ExCO₂) level of the exhaled gas expired by the patient within the breathing circuit; a flow rate signal indicative of the flow rate (V) of the inhaled/exhaled gas expired by patient within the breathing circuit; a pulse oximeter hemoglobin oxygen saturation (SpO₂) signal indicative of the oxygen saturation level of the patient; a pressure (P) signal indicative of the pressure of the breathing gas within the breathing circuit; a blood pressure (BP) signal indicative of the blood pressure of the patient; and a temperature (T) signal indicative of the core body temperature of the patient.

3. The method of Claim 2, wherein the output signals also comprise at least one of: an arterial blood gas PaO₂ signal; an arterial blood gas PaCO₂ signal; and an arterial blood gas pH signal.

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8. The method of Claim 7, wherein the processing subsystem has a neural network, and wherein determining the desired level settings of the ventilator setting controls of the ventilator further comprises applying at least a portion of the ventilation data and the ventilator setting parameter signal to the neural network of the

9. The method of Claim 7, wherein the processing subsystem has a neural network, and wherein the step of determining the desired level settings of the ventilator setting controls further comprises:

applying a portion of the ventilation data and the ventilator setting parameter signal to the neural network; and

determining at least one desired level settings of the ventilator setting controls of the ventilator from the applied portion of the ventilation data and the ventilator setting parameter signal.

10. A method for differential determination of a plurality of desired level settings of a ventilator having selectable ventilator setting controls, each setting control selectable to a level setting, the method comprising:

supplying a breathing gas from the ventilator to a patient via a breathing circuit in fluid communication with the ventilator and at least one lung of the patient;

receiving a plurality of output signals indicative of the physiological characteristics of the patient and the characteristics of the breathing gas supplied to the patient;

receiving a plurality of ventilator setting parameter signals indicative of the level settings of the ventilator setting controls;

deriving a plurality of ventilation data from the output signals;

selecting at least a portion of the ventilation data and at least a portion of the ventilator setting parameter signals;

converting the selected portion of the ventilation data and the selected portion of the ventilator setting parameter signals into numerical expressions;

inputting a plurality of the transformed numerical expressions into a neural network; and

determining at least one of the desired level settings of the ventilator setting controls using the neural network in accordance with the input numerical expressions.

11. The method of Claim 10, further comprising training the neural network to determine each of the desired level settings of the ventilator setting controls using the ventilation data and the ventilator setting parameter signals.

12. The method of Claim 11, further comprising dividing the determination of the desired level settings of the ventilator setting controls into a plurality of stages using a plurality of neural networks.

13. The method of Claim 11, wherein the neural network includes a plurality of parallel neural networks, each of the parallel neural networks having a plurality of inputs and one output, the outputs respectively corresponding to the plurality of setting controls, so that one output corresponds to one desired level setting of one ventilator setting control.

14. The method of Claim 10, wherein deriving the ventilation data comprises deriving a plurality of: pressure (P) of the breathing gas within the breathing circuit; flow rate (V) of the breathing gas within the breathing circuit; exhaled carbon dioxide (ExCO₂) in the breathing gas within the breathing circuit; peak inflation pressure (PIP); mean airway pressure (Paw); positive end expiratory pressure (PEEP); continuous positive airway pressure (CPAP); breathing frequency (f); tidal volume (V_T); minute exhaled ventilation (V_E); inhalation-to-exhalation time ratio (I:E); physiological dead space volume (V_{dphys}); lung carbon dioxide elimination rate (LCO₂); partial pressure end-tidal carbon dioxide (PetCO₂); respiratory muscle

1. The first step is to identify the problem or goal. This involves understanding the current situation and what needs to be achieved.

16. The method of Claim 10, wherein the neural network comprises a plurality of input units, a plurality of hidden layers having a plurality of hidden units, and a plurality of output units, the output units respectively corresponding to the plurality of ventilator settings.

18. The method of Claim 10, further comprising displaying at least one of the plurality of desired level settings for the ventilator setting controls of the ventilator.

19. A ventilation support monitoring system for a ventilator supplying a breathing gas to a patient via a breathing circuit in fluid communication with at least one lung of a patient, the ventilator having a plurality of selectable ventilator setting controls for governing supply of the breathing gas from the ventilator to the patient, each setting control selectable to a level setting, and each ventilator setting control generating a ventilator setting parameter signal indicative of the current level setting of the ventilator setting control, the system comprising:

an input that receives at least one ventilator setting parameter signal;

a plurality of sensors for measuring a plurality of ventilation support parameters, each sensor operatively connecting to a select one of the patient or the breathing circuit, wherein each sensor generates an output signal based on the measured ventilation support parameter; and

a processing subsystem connected to receive the output signals from the sensors and the ventilator setting parameter signal from the input, the processing subsystem having a processor and a memory, the processor running under control of a program stored in the memory, the processing subsystem having an intelligence system to determine a desired level setting of at least one ventilator setting control in response to the ventilator setting parameter signal and the output signals.

20. The system of Claim 19, wherein the plurality of ventilation support parameters is selected from the group comprising: the flow rate (V) of the exhaled gas inspired/expired by patient within the breathing circuit; the exhaled carbon dioxide (ExCO₂) level of the exhaled gas expired by the patient within the breathing circuit; the hemoglobin oxygen saturation (SpO₂) level of the patient; the pressure (P) of the breathing gas within the breathing circuit; the blood pressure (BP) of the patient; and the core body temperature (T) of the patient.

21. The system of Claim 20, wherein the means the plurality of ventilation support parameters also includes at least one of: the arterial blood gas PaO₂ level of the

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23. The system of Claim 19, further comprising a display, wherein the processing subsystem provides the desired level settings of the ventilator setting controls to the display.

24. The ventilator of Claim 19, further comprising an alarm for notifying an operator of the ventilator that the level settings of the ventilator setting controls differs from the determined desired level settings of the ventilator setting controls.

25. The system of Claim 19, wherein the desired level setting for the ventilator setting control of the ventilator comprises at least one of: a minute ventilation (V_E) level indicative of the desired V_E level to set on the ventilator; a ventilator breathing frequency (f) level indicative of the desired f level to set on the ventilator; a tidal volume (V_T) level indicative of the V_T level to set on the ventilator; a breathing gas flow rate (V) level indicative of the V level to set on the ventilator; a pressure limit

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the processing subsystem has at least one neural network ; and
the processor, in determining the desired level settings of the ventilator setting controls, generates a plurality of ventilation data from the output signals of the sensors and applies at least a portion of the ventilation data and at least a portion of the ventilator setting parameter signal to the neural network to generate the desired level settings of the ventilator setting controls.

27. The system of Claim 26, wherein the processing subsystem is programmed with a set of decision rules and wherein the processor applies the set of decision rules to the ventilation data prior to applying the portion of the ventilation data and the portion of the ventilator setting parameter signal to the neural network.

28. The system of Claim 26, further comprising a display, wherein the processing subsystem identifies ventilation data used to determine the desired level settings of the ventilator setting controls, identifies a subset of the ventilation data for display, and provides the subset of the ventilation data to the display, and wherein the processing subsystem provides the desired level settings of the ventilator setting controls to the display.

means for inputting a plurality of the transformed numerical expression into the neural network so that the desired level settings of the ventilator setting controls are determined in accordance with the input numerical expressions.

means for training the neural network using the statistically significant training data sets so that the desired level settings of the ventilator setting controls are determined based upon selected output signals and selected level settings of the ventilator setting controls.

31. ~~A ventilation support monitoring system for a ventilator supplying a breathing gas to a patient via a breathing circuit in fluid communication with at least one lung of~~

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a processor having a memory, the processor connected to receive output signals from the sensors and the ventilator setting parameter signals from the input and running under control of a program stored in the memory to generate a plurality of ventilation data from the output signals, to apply at least a portion of the ventilation data and at least a portion of the ventilator setting parameter signals to the neural network to determine the desired level settings of the ventilator setting controls.

32. The system of Claim 31, wherein the plurality of ventilation support parameters comprises one or more of: the flow rate (V) of the exhaled gas inspired/expired by patient within the breathing circuit; the exhaled carbon dioxide (ExCO₂) level of the exhaled gas expired by the patient within the breathing circuit; the hemoglobin oxygen saturation (SpO₂) level of the patient; the pressure of the breathing gas within the breathing circuit; the blood pressure (BP) of the patient; and the core body temperature (T) of the patient.

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system of Claim 34, further comprising a display, wherein the processing provides the desired level settings of the ventilator setting controls to the

system of Claim 31, wherein the desired level settings for the ventilator controls include at least one of the group comprising: a minute ventilation (V_E) level indicative of the desired V_E level to set on the ventilator; a ventilator breathing frequency (f) level indicative of the desired f level to set on the ventilator; a tidal volume (V_T) level indicative of the V_T level to set on the ventilator; a breathing gas flow rate (V) level indicative of the V level to set on the ventilator; a pressure limit level indicative of the pressure limit level to set on the ventilator; a work of breathing level indicative of the WOB level to set on the ventilator; a pressure support level (PSV) indicative of the PSV level to set on the ventilator; a positive end-expiratory pressure (PEEP) level indicative of the PEEP level to set on the ventilator; a continuous positive airway pressure (CPAP) level indicative of the CPAP level to set on the ventilator; and a fractional inhaled oxygen concentration (FIO2) level indicative of the FIO2 level to set on the ventilator.

system of Claim 31, wherein the processor is programmed with a set of decision rules and wherein the processor applies the set of decision rules to the ventilation data prior to applying the portion of the ventilation data and the portion of the ventilator setting parameter signal to the neural network.

system of Claim 33, wherein the processing subsystem identifies the ventilation data used to determine the desired level settings of the ventilator setting controls; identifies a subset of the ventilation data for display; and provides the subset of ventilation data to the display.

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system of Claim 34, further comprising a display, wherein the processing provides the desired level settings of the ventilator setting controls to the

system of Claim 31, wherein the desired level settings for the ventilator controls include at least one of the group comprising: a minute ventilation (V_E) level indicative of the desired V_E level to set on the ventilator; a ventilator breathing frequency (f) level indicative of the desired f level to set on the ventilator; a tidal volume (V_T) level indicative of the V_T level to set on the ventilator; a breathing gas flow rate (V) level indicative of the V level to set on the ventilator; a pressure limit level indicative of the pressure limit level to set on the ventilator; a work of breathing level indicative of the WOB level to set on the ventilator; a pressure support level (PSV) indicative of the PSV level to set on the ventilator; a positive end-expiratory pressure (PEEP) level indicative of the PEEP level to set on the ventilator; a continuous positive airway pressure (CPAP) level indicative of the CPAP level to set on the ventilator; and a fractional inhaled oxygen concentration (FIO2) level indicative of the FIO2 level to set on the ventilator.

system of Claim 31, wherein the processor is programmed with a set of decision rules and wherein the processor applies the set of decision rules to the ventilation data prior to applying the portion of the ventilation data and the portion of the ventilator setting parameter signal to the neural network.

system of Claim 33, wherein the processing subsystem identifies the ventilation data used to determine the desired level settings of the ventilator setting controls; identifies a subset of the ventilation data for display; and provides the subset of ventilation data to the display.

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system of Claim 34, further comprising a display, wherein the processing provides the desired level settings of the ventilator setting controls to the

system of Claim 31, wherein the desired level settings for the ventilator controls include at least one of the group comprising: a minute ventilation (V_E) level indicative of the desired V_E level to set on the ventilator; a ventilator breathing frequency (f) level indicative of the desired f level to set on the ventilator; a tidal volume (V_T) level indicative of the V_T level to set on the ventilator; a breathing gas flow rate (V) level indicative of the V level to set on the ventilator; a pressure limit level indicative of the pressure limit level to set on the ventilator; a work of breathing level indicative of the WOB level to set on the ventilator; a pressure support level (PSV) indicative of the PSV level to set on the ventilator; a positive end-expiratory pressure (PEEP) level indicative of the PEEP level to set on the ventilator; a continuous positive airway pressure (CPAP) level indicative of the CPAP level to set on the ventilator; and a fractional inhaled oxygen concentration (FIO2) level indicative of the FIO2 level to set on the ventilator.

system of Claim 31, wherein the processor is programmed with a set of decision rules and wherein the processor applies the set of decision rules to the ventilation data prior to applying the portion of the ventilation data and the portion of the ventilator setting parameter signal to the neural network.

system of Claim 33, wherein the processing subsystem identifies the ventilation data used to determine the desired level settings of the ventilator setting controls; identifies a subset of the ventilation data for display; and provides the subset of ventilation data to the display.

38. The ventilator of Claim 31, further comprising:
an alarm signal produced by the processing subsystem when at least one level setting of the ventilator setting control differs from the desired level setting for that ventilator setting control; and
one or more of an audible and visible alert in response to the alarm signal to alert the operator.

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